Influence of the free exchange in early-age on the delayed deformations under constant load of eco-concrete formulated with rubber waste

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ABSTRACT:

The classic characteristics of concrete at early age are well known, inversely little about the behavior of rubberized concrete at early age, the work presented here aims at analyzing the endogenous and total delayed behavior of rubberized concrete.
In order to study the endogenous and total delayed deformation under constant load, a well defined composite of voluminal proportion of aggregate (30%) and a aggregate 4-6 size was studied for different curing time. For each curing time the delayed deformations were measured in a configuration of free exchange and in the case of specimens sealed.
The experimental measurements have shown that the presence or absence of a free exchange has a significant influence on the delayed deformations under constant load.

KEYWORDS: *Rubber waste aggregates, Rubberized concrete, endogenous delayed deformation under constant load, desiccation delayed deformation under constant load, Total delayed deformation under constant load, early-age*

1. Introduction

The development of materials is a fundamental cultural element of the history of humanity. The opportunities of materials which can be recycled increasingly many and are varied. Recycling quickly seemed a solution with a future, it makes it possible to reduce the impact of waste on the environment and falls under a logic of sustainable development, although recycling is a very old idea, the change of the current society returns the collection, the transformation and the re-employment of waste an principal activity, the valorization of worn tires represents a big challenge, the channels of treatment were already installation mainly in the form of valorization energy or of valorization matter, but the environmental impact requires to envisage other channels of recycling.
The introduction of aggregates used tires in concrete has been the subject of many research works. As examples, [Topçu, 1995; Eldin N. & al, 1993; Ali N.A & al, 1993], studied the mechanical behavior of the rubber concretes, [D. Raghavan & al, 1998] studied the influence of the form of rubber inclusions on the rheological and physicomechanical properties of mortars in a fresh and hardened state. In the form of fibers, they improve the mechanical resistances and the withdrawal of drying, [N.N. Eldin & al, 1993] studied the case of a concrete in which the mineral sand and fine gravels are substituted, independently, by rubber aggregates containing of metal fibers. They showed that the substitution of the fine gravels decreases the mechanical performances in a way more important than that of sand. However, the incorporation of rubber aggregates confers on material a ductile behavior, with a great capacity for plastic absorption of energy under loading in compression and traction. These observations were also reported by [Khatib Z.K. & al, 1999; Topçu U.B. & al, 1997; Biel T.D. & al, 1996] studied influences it type of cement on the compressive strength of the rubber concretes. [A. H. Toutanji, 1996] it highlighted not linearity of the relation between the fall of the compressive strength and the voluminal content of rubber aggregates. Moreover, the decrease is faster than for the flexural strength. It in addition showed that the deformation of the concrete under loading is clearly improved in the presence of aggregates of rubber. [NAIK T.R. & al, 1995; Fattuhi N.I & al, 1996; Siddique R. & al, 2004] showed the use potential of the rubber concretes in several fields in spite of the reduction of the mechanical resistances. The Engineering Materials and Processes (EMAP) of LTI (EA 3899) was also interested in valorization of scrap rubber in cementing composites and showed the feasibility of these materials, their characterization and the physicomechanical and thermal properties of these composites like their durability [H.G. Essoba & al, 2005; B. Laidoudi & al, 2003; A. Benazouk & al, 2004; F. Labbani & al, 2004; F. Labbani & al, 2005; B. Laidoudi, 2005]. However, the behavior in time under constant load had not been studied to date in spite of its importance in the anticipation of the behavior of materials in service. An experimental study of the influence of the free exchange to the early-age was thus undertaken.

2. Materials used

The cement used for this study is of type CEM I 52,5 R produced by the factory Gourain (company of Belgian cements). The choice of this type of cement is justified by the fact that it develops high resistances and thus makes it possible to compensate for the negative influence of the rubber aggregates on the resistance of the cementing composite.
The compact rubber aggregates are obtained by crushing of worn tires. Metal and the textile are eliminated. Crushed rubber is filtered in order to have various granulometry. We used a size range: 4-6 for the compact aggregates.

3. Experimental techniques

Table 1 gives the composition of the composite used in this work.

Table 1: Mix Design

Components	Unit	CGCC 4-6 30%
Cement	Kg/m^3	1312.45
Water	Kg/m^3	414.08
Water / Cement		0.315
GCC 4-6	Kg/m^3	226.04

It is specified that ratio E/C is given to have a constant handiness The percentages of rubber aggregates used in this work are 30%. The rubber aggregates and cement are mixed at the dry state in a mixer standardized (standard EN 196 - 1) of capacity five liters. Dry malaxation lasts two minutes in order to ensure a good dispersion of the rubber aggregates. The mixing water is added gradually at slow speed during two minutes, malaxation continues one minute at fast speed.

The resulting mixture is set up in moulds of dimensions 3 X 10 mm. The test-tubes are preserved before and after the release from the mould in room at temperature and hygroscopy controlled (20°C, HR = 98%) during 28 days then dried until constant mass before the tests. To measure the delayed deformations under constant load we designed and dimensioned a bench of creep. The objective was to virtually test the resistance of each part to support the load necessary without disturbing measurements of delayed deformation under load.

The device of measurement is composed of several elements, whose sensor is the first link. Its choice is determining and depends mainly on the physical size to measure what means that the quality of measurement is related in major part to quality of the sensors.

We used sensors of the numerical feeler type `'digital probe' '. The feelers have the advantage of the robustness and reliability. They are of a high degree of accuracy and allow absolute measurements because they do not require to be re-initialized in the event of power cut.

The system of acquisition is also an important part of the device of measurement. We chose the chart network orbits. The chart is designed to adapt in a slit PCI on the mother chart of a computer having at least a processor, functioning to 700 MHz and having a RAM of at least 128MB. The chart accepts 62 numerical feelers. Each sensor connected on the network is identified by its single address. Measurements of these 62 feelers are done simultaneously. Just as the numerical feelers, the chart network orbits has a high degree of accuracy; its setting goes request from there certainly more efforts but it is very definitely less expensive than the traditional power stations of acquisition.

The follow-up of the variation height of the cylindrical test-tubes with a diameter 3 cm and height 10 cm according to time is made in a room air-conditioned and maintained with 20°C. The test-tubes are subjected to a uniform compressive force maintained constant over one long period. The pressure applied corresponds to 30% of the mechanical resistance in compression, the acquisition of the values is computerized.

4. Results and discussion

Figure 1 illustrates the conventional decomposition of the delayed deformations

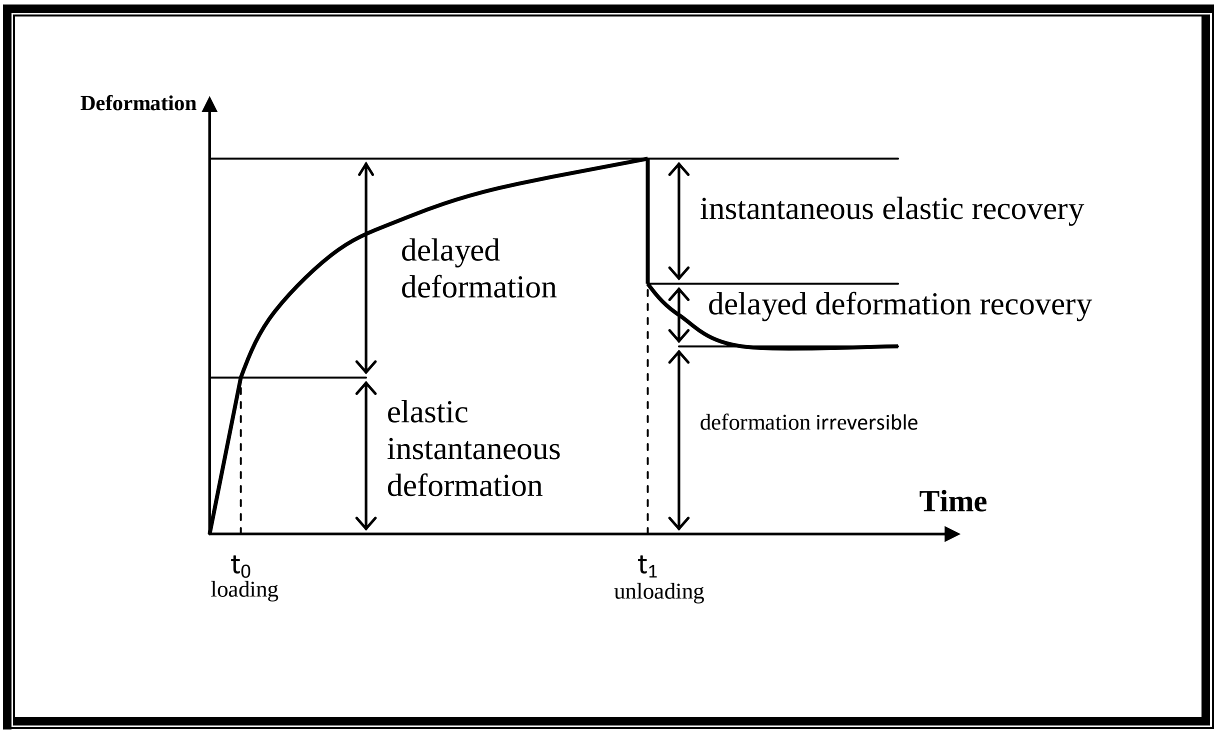

Fig.1. Conventional Decomposition of the Delayed Deformations

The delayed deformation measured on a test-tube charged is in fact the sum of several delayed deformations:

* Delayed deformation without load until the loading
* Elastic instantaneous deformation at the time of the loading
* Combination of the delayed deformation without load and the deformation due to the load after loading, during all the test.

Let us recall that

- The elastic instantaneous deformation is the deformation occurring simultaneously with the application of the constraint, it depends on the value of the constraint, the speed of application of the constraint and the age of the concrete.
- The delayed deformation without load starts at the beginning of setting and continuous for one long period.
- Creep is defined as the time-dependent deformation resulting from a sustained stress.
- The total deformation at the moment t and a constant temperature, is the sum of the deformation without load, the instantaneous deformation and creep
- The instantaneous elastic recovery is the deformation occurring simultaneously with unloading
- The recouvrance is the reversible part of the delayed deformation under load without instantaneous deformation after unloading

The study of the influence of the free exchange in early-age was carried out for the various durations

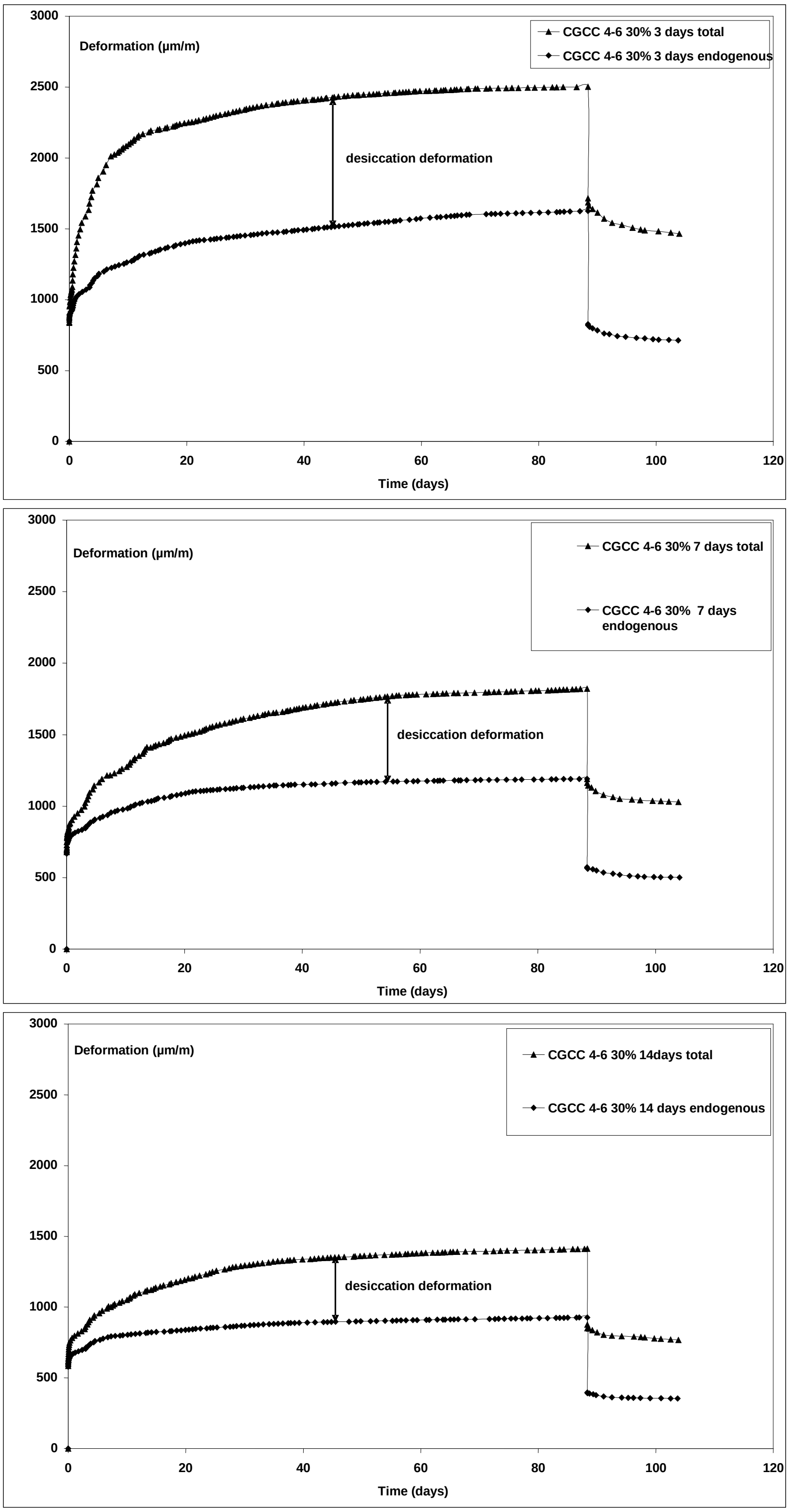

Fig.2. Total delayed deformation under load with and without exchange

The figure (1) shows various evaluated deformations.

Table 2 summarizes the values of delayed deformations under load for the various composites. This table will make it possible to study the evolution of the distribution between the fundamental delayed deformation and the desiccation delayed deformation.

Table 2: Values of total and fundamental delayed deformations under load for the various composites

	elastic instantaneous deformation (µm/m)	total delayed deformations (µm/m)	instantaneous elastic recovery (µm/m)	delayed recouvrance (µm/m)	residual deformation (µm/m)
CGCC 4-6 30% 3 days free	837.25	2501.91	787.12	249.36	1465.42
CGCC 4-6 30% 3 days fundamental	852.01	1625.02	796.59	115.65	712.76
CGCC 4-6 30% 7 days free	679.45	1820.96	631.82	159.64	1029.49
CGCC 4-6 30% 7 days fundamental	668.48	1190.5	618.28	70.46	501.75
CGCC 4-6 30% 14 days free	583.23	1412.82	535.98	109.08	767.75
CGCC 4-6 30% 14 days fundamental	579.54	926.87	530.27	43.41	353.18

we recall that the test-tube are preserved before and after the release from the mould in room at temperature and hygroscopy controlled (20°C, HR = 98%) respectively during 3 days, 7 days and 14 days, the end of 3rd day and the beginning of 4th, the end of 7th and the beginning of 8th, the end of 14th and beginning of 15th respectively it is the moment t_0 of beginning of the test.

The delayed deformation under constant load can be broken up into two parts which we called: endogenous delayed deformation and desiccation delayed deformation. The endogenous or fundamental delayed deformation occurs when there is no exchange of moisture between material and the ambient conditions. The desiccation or drying delayed deformation is an additional component which occurs when it material and exposed to conditions of drying. The sum of these two components gives the total delayed deformation (Figure 2). To obtain these components, of measurements are carried out on test-tubes in hydrous free exchange with the external medium and on identical test-tubes made tight. The desiccation delayed deformation is obtained by subtraction of the two curves obtained (Figure 2).

Concerning the elastic instantaneous deformation, we can see logically that the fact of working with or without exchange with outside does not modify its value.

From Table 2, we can give the distribution between the fundamental delayed deformation under load and the desiccation delayed deformation under load. If we submit the relationship between the fundamental delayed deformation and the total delayed deformation from the test-tubes in free exchange with the ambient conditions, we find a rate of fundamental delayed deformation under load of about 65% whatever the curing time.

5. Conclusion

In this study, we showed the influence of the free exchange in early- age on the delayed deformation under constant load from the composites concrete-rubber. The results confirm the possibility of developing scrap rubber in the form of light concrete of construction for voluminal proportions of rubber of about 30%, from where the need for continuing the study for other formulations and for studying the influence of the free exchange for other ages in order to better know the specificity of behavior differed from each composite for each age and for confirming the diversity of the applications of materials according to the needs.

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